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(54) PULP

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ABSTRACT OF THE DISCLOSURE

Dry wood pulp is prepared by thermomechanically pulping wood chips and drying the pulp so formed by contacting it with a gas at a temperature of 300-600°C in or at the entry of a high turbulence mixer through which the pulp and hot gas pass and which exerts a shearing action on the pulp to separate fibre bundles in the pulp. The ratio of moisture to dry wood solids is maintained at less than 5:1 throughout the process. The pulp is suitable for use as fluffing pulp or can be used to directly feed a dry forming paper-making or board-making process.

This invention relates to dry wood pulp suitable for example for use as fluffing pulp or for dry paper- or board-making.

In a conventional pulping process logs of wood are stone-ground to pulp. Cooling water is used to control the temperature of the grinding process and the product obtained is a dilute slurry of wood pulp in water. The process uses great quantities of water and produces great quantities of aqueous effluent which has to be treated.

An alternative known process for comminuting wood into pulp is thermomechanical pulping. In this process wood chips are first pre-heated and then confined between two opposed grinding surfaces, generally rotating discs. The pre-heated wood chips are introduced at or near the centre of the wood pulping machine and have to pass outwards through the grinding zone of the outlet. The heat generated by the grinding process converts water present in the wood chips to steam. Water is added during the thermomechanical pulping generally at such a rate as to keep the moisture content of the wood chips approximately constant. The wood being pulped is thus constrained within a high pressure steam zone at a temperature of 100°C or above.

The pulp produced by thermomechanical pulping usually has a moisture content similar to that of the wood from which it was made. If it is to be dried as pulp it is usually screened to remove shives and also treated to relax the pulp fibres and to make them bond together more readily. The relaxation treatment involves suspension of the wood pulp fibres in hot water. To carry out screening satisfactorily the pulp is diluted to

give a ratio of moisture to dry wood fibre solids of at least 30:1 by weight. The whole production process still uses considerable quantities of water.

According to the present invention a process for the preparation of dry wood pulp comprises thermomechanically pulping wood chips and drying the pulp so formed by contacting it with a gas at a temperature of 300-600°C in or at the entry of a high turbulence mixer through which the pulp and hot gas pass and which exerts a shearing action on the pulp to separate fibre bundles in the pulp, the ratio of moisutre to dry wood solids being maintained at less than 5:1 by weight throughout the process. While the invention includes processes in which the ratio of moisture to dry wood fibre solids in the pulp approaches 5:1 it is preferred that this ratio is maintained at less than 3:1 and indeed that the moisture content of the wood is not substantially increased at any stage. The ratio of moisture to dry wood fibre solids in a living tree is generally between 2:1 and 3:1. Wood as supplied to the pulping factory commonly has a ratio of moisture to dry wood fibre solids of between 1.5:1 and 2.5:1 and this moisture content is suitable for thermomechanical pulping.

We have found that the process of the present invention produces a dry wood pulp which is particularly suitable as fluffing pulp for use in water-absorbing materials such as incontinence pads, disposable diapers, sanitary towels and the like. The dried wood pulp produced by the invention is also suitable for use in a dry paper- or board-making process.

The thermomechanical pulping process can be carried out in a single pulping machine (which is generally of the type known as a double disc refiner) or two or more machines can be successively used to pulp the wood. The wood chips are pre-heated before being fed to the double disc refiner for example by treating the chips with live steam. The amount of moisture added to the chips by this steam pre-heating is small, usually less than 15 per cent. Our preferred procedure for thermo-mechanical pulping comprises a pre-heating step using live steam at a temperature of from 105° to 135°C and a single pulping step in a double disc refiner at a temperature lower than that used for pre-heating and of from 100° to 110°C. The steam generated in the double disc refiner can be used to provide some of the steam for pre-heating the wood chips. A bleaching agent can if desired be introduced into the double disc refiner to bleach the wood pulp during the pulping process.

The drying process is carried out in a high turbulence mixture. The wood pulp, which is usually at the moisture content at which it is discharged from the thermomechanical pulping machine, and a gas, generally air, at 300 to 600°C are both fed to the mixer and contact each other in or at the entry to the mixer. The mixer is designed to exert a shearing action on the pulp. It may for example be fitted with hammers working against a surface and/or intermeshing and relatively rotating spikes or pegs. The shearing action breaks up agglomerated bundles of wood fibres in the pulp. One example of a suitable high turbulence mixer is that sold under the

trade mark "Atritor".

The high turbulence mixture also disperses the wood pulp fibres rather evenly in the air flowing through the mixture. It preferably acts so quickly that the temperature of the stream of hot gas falls to 100°C within one second of contacting the pulp. This suspension of fibres in air can if desired be used in immediate subsequent treatment such as depositing the fibres on a screen.

When the process of the invention is used for making paper or board, the wood can be pulped and dried and the dry pulp fibres stored for subsequent use, but it is preferred that the high turbulence mixer be used as a dryer directly feeding the paper-making or board-making process.

At the paper- or board-making machine a stream of gas, generally air, carries the fibres through a screen and deposits them as a layer on a forming surface. Various dry forming paper- and board-making machines are known. In known processes the wood fibres are usually supplied to these machines as fluffed dried pulp which may for example be dried pulp which has been treated in a hammer mill to get it in a suitable form for suspension in an air stream. The stream of air containing the fibres is passed through a forming surface which is permeable by the air but on which the fibres are deposited as a layer.

The apertures in the screen through which the stream of air must pass before it reaches the forming surface are of a size to allow passage of separated wood fibres of a size suitable in incorporation in the grade of paper or board being made but will not allow passage of agglomerated fibre bundles or

shives. The dry forming machine preferably has a stirring or scraping device ensuring that the screen does not become blocked by fibre bundles and shives and preferably has a waste outlet designed so that the agglomerated fibre bundles and shives are removed from the machine without it being necessary to halt the paper making process. In an integrated operation the shives and similar material collected from the waste outlet can be recycled to the inlet of the thermomechanical pulping apparatus.

The air stream containing the wood fibres after passing through the perforated screen impinges on the paper forming surface. This can be a fine mesh screen or a gas permeable web or fabric.

The stream of gas used to carry the wood fibres through the perforated screen to the paper forming surface can be provided in a known manner, for example by a suction box positioned beneath each dry forming machine. Alternatively, or additionally, the stream of air issuing from the dryer can carry the wood fibres right through to the pulp forming surface. It may, however, be preferred to separate the fibres from the moisture laden air issuing from the dryer, for example in a cyclone separator.

The stream of air containing wood fibres which issues from the dryer feeds one or more dry forming machines. Usually one double disc refiner and high turbulence dryer can feed several dry forming machines. These can be arranged in sequence particularly when forming board. When the fibres from one machine are deposited on the layer of fibres deposited by the previous machine then board consisting of a number of layers of

fibres can be formed from the output of one double disc refiner and dryer.

After being laid on the fibre forming surface the paper or board undergoes various consolidating treatments. It is generally treated with a liquid binder, for example by spraying. Examples of binders are starch and starch derivatives and polymer latex emulsions. Subsequently it is usually subjected to pressure to consolidate the web and to drying to remove moisture applied in the binder spray. It can also be sized, coated, embossed and/or calendered.

Paper and board made from wood pulp obtained by the process according to the invention need not consist exclusively of the thermomechanically pulped fibres. If desired one or more outer layers made from covering stock, for example chemical pulp, can be used to cover one or more layers formed of wood pulp obtained by the process according to the invention. For example, to make cardboard the first layer of fibres laid on the paper forming surface can be formed from chemical pulp fed to a dry forming machine. Several subsequent layers of board can be successively laid on top of this outer layer from different dry forming machines which may all be fed from the same thermomechanical pulping machine and dryer. The last layer applied can be a further layer formed from covering stock. The combined board can then be treated with binder and consolidated as described above.

The above described process provides a method of making paper or board which requires no, or very little, water and

discharges very little polluted water. It need not be sited near a large water supply. Moreover it can be used economically on a much smaller scale than a conventional wet pulping and paper-making process. It can for example be sited in or near a forest of moderate size for example 10,000 acres whereas a conventional paper-making factory of economic scale requires a forest at least ten times as big.

When the pulp produced by the thermomechanical pulping machine and the high turbulence dryer is to be used as fluffing pulp it can be collected loose to be packed in bales or sheets. In one preferred procedure, however, the pulp issuing from the dryer is deposited on a gas permeable surface as a layer and has the form of a coherent sheet of fluffing pulp.

The pulp issues from the dryer as a suspension of wood fibres in air. This is arranged to impinge on a permeable surface which can be in the form of a rotating drum or a flat moving belt. A suction device is preferably used to apply vacuum to the other side of the permeable surface to ensure that the wood pulp fibres are firmly held on the permeable surface. In one preferred procedure the permeable surface is part of a vacuum drum. The wood pulp fibres are initially strongly held on the drum by suction but as the layer of wood pulp fibres builds up on the drum the air flow through it decreases. The suction device preferably covers only part of the drum and the layer of wood pulp fibres can be carried off the drum, for example onto a flat conveyor, at a point on the drum where suction is not applied, for example approximately opposite to that at which fibres are first deposited on it.

The layer of wood pulp fibres is preferably arranged to have a basis weight of 500-5000 grams per square metre. It requires consolidation, for example at a pressure of about 350 kgs per square centimetre, to form a coherent sheet that can be handled without falling apart. Consolidation can be by a platen press in which case the fibrous layer is generally cut into separate sheets before pressing or by pressure rolls in which case continuous or separate sheets can be formed.

The dry wood pulp formed by thermomechanically pulping and high turbulence drying according to the invention has undergone no relaxing treatment in water and readily forms a bulky fluffed pulp. The sheets of consolidated pulp are particularly easily broken into wood fibres by pulp fluffing apparatus for example a hammer mill. Moreover, the pulp can be consolidated by pressure to a relative density of 0.5 to 1 and still undergo this easy integration whereas pulp produced by conventional processes cannot be consolidated to a relative density above 0.5 or it will not disintegrate satisfactorily. This is a particular advantage if the sheets of pulp have to be transported from the pulp mill to the manufacturer of absorbent products.

The invention will now be described by way of example with reference to the accompanying drawings in which

Figure 1 is a diagrammatic side elevation partly in section of an apparatus suitable for producing dry wood pulp by the process according to the invention and forming this pulp into paperboard, and

Figure 2 is a diagrammatic side elevation partly in section of an apparatus suitable for producing fluffing pulp using the process according to the invention.

The apparatus shown in Figure 1 comprises generally a pre-heater 1, a thermomechanical pulping machine 2, a dryer 3, a dispensing unit 4 for the wood fibres, a dry forming machine 5 and a web consolidation unit 6.

Wood chips are fed to the pre-heater 1 through an inlet 11. The pre-heater is in the form of a screw conveyor. The residence time of the wood chips in the pre-heater can be controlled by controlling the speed of the screw conveyor and is preferably from 0.5 to 3 minutes. Steam is fed to the pre-heater 1 through an inlet 15.

Wood chips emerging from the pre-heater 1 pass through a rotary valve 17 and a chamber 18 to a feeder 19 which is a screw conveyor. It feeds the wood chips to the thermomechanical pulping machine 2.

The pulping machine 2 is a double disc refiner comprising two contra-rotating discs 31, 32 mounted on shafts 33, 34, respectively, which rotate about a common axis. The discs 31 and 32 have confronting grinding surfaces 35 and 36, respectively, separated by a narrow gap 41. Wood chips are fed by the feeder 19 to a chamber 37 behind the disc 31. From this chamber 37 the wood chips pass through two inlet ports 38 and 39 in the disc 31 to the central region 40 of the double disc refiner. To pass out of the pulping machine 2, the wood chips must pass through the gap 41 from the central region 40 to the rim 42 of the discs. The wood chips are ground to pulp in the gap 41.

Water is supplied to the double disc refiner through an inlet 43 feeding a chamber 44. The water passes to the central region 40 of the double disc refiner through ports 45 and 46 in the disc 32. The heat generated in the grinding causes some of the water in the wood chips and added through the ports 45 and 46 to be released as steam. The steam can vent back through the ports 38 and 39, the chamber 37 and the feeder 19 to the chamber 18. The chamber 18 is provided with a vent pipe 22 controlled by a valve 23, so that when excess pressure of steam builds up in chamber 18 it can be vented out of the apparatus. The amount of water supplied to the inlet 43 is controlled so that the moisture content of the wood chips is kept approximately constant. The temperature in the thermomechanical pulping machine 2 is thus prevented from becoming too high.

Pulp emerging from the pulping machine 2 falls on to a screw conveyor which feeds the pulp to the flash dryer 3 via a pipe 47. Hot air, for example a temperature from 400° to 500°C, is produced in an air heater 48, heated by a burner 49, and is supplied to the dryer through a pipe 50. The hot air contacts the pulp at the inlet chute 51 of the dryer.

The dryer 3 is a high turbulence mixer in which the hot air and wood pulp are rapidly mixed, agglomerated bundles of wood pulp fibres are broken up and the dried wood fibres are carried away in a stream of the hot air. The dryer 3 comprises a rotary disc 52, a stationary disc 53 and an extractor fan 54. The rotary disc 53 carries on one side hammers 55 which work against the wall of the dryer and on the other side carries pegs 56. The pegs 56 intermesh with pegs 57 mounted on the stationary disc 53. The wood pulp and

air entering dryer 3 via the inlet chute 51 have to pass the hammers 55, which serve to break up fibre bundles, and then between the pegs 56 and 57, which evenly disperse the fibres in the flow of air. The air and fibres then pass through an opening 58 at the centre of the stationary disc 53, which opening is controlled by a valve 59. Thence they are forced by the extractor fan 54, which is mounted on the same shaft 60 as disc 52 and valve 59, to the exit 61 of the dryer 3.

The stream of air carrying the wood fibres of the pulp emerges from dryer 3 through a pipe 62 and conveys them to the dispensing unit 4. The air pipe 62 feeds six inlet pipes such as 63a feeding six cyclone separators 64a to 64f, respectively. The entry, for example 65a, to each inlet pipe 63 is adjusted, for example by a butterfly valve, so that substantially equal quantities of fibres are supplied to each of the cyclone separators 64a to 64f. Each cyclone separator 64 is a conical rotary separator discharging the moisture laden air through a top outlet, such as 66a, and the wood fibres through a base outlet such as 67a.

The cyclone separators 64a to 64f are mounted above the dry forming board-making machine 5. Each of the cyclone separators 64a to 64f feeds wood fibre through its base outlet to fibre dispensers 68a to 68f, respectively.

Each of the fibre dispensers 68a to 68f can be of the type described in British Patent Specification No. 1,207,556. Thus, as shown in the case of the dispenser 68a, each dispenser consists of a housing 69 whose lower surface is a flat screen 70 having apertures large enough to permit the passage of wood fibres suitable for making board but fine enough to prevent the passage of agglomerated fibre bundles and shives. Two or more stirrers 71

hover above the screen 70, rotating in a panetary motion.

The wood fibres enter the dispenser 68a through an inlet 72 at one side of the housing 69, and the stirrers 71 serve to distribute the fibres uniformly across the screen 70. Shives and fibrous lumps which will not pass through the screen 70 are moved along the screen to an oulet 73 at the opposite side of the housing from the inlet 72. From the outlet 73 the shives pass through a pipe 74 to a conveyor 75 where they join the material rejected from the dispensers 68b to 68f and are returned to the inlet 11 of pre-heater 1. The rate of feed of wood fibres to each of the dispensers 68a to 68f compared to the rate at which fibres pass through the screen 70 is generally such that about one-third of the weight of wood fibre is rejected through the outlet 73.

The fibre dispensers 68a to 68f are mounted above the dry forming board-making machine 5. So are two more dispensers 79 and 80 of the same design as the fibre dispensers 68a to 68f. The dispensers 79 and 80 receive wood fibres from cyclone separators 81 and 82, respectively. The inlet pipes 83 and 84 of the cyclone separator 81 and 82 are not fed from the air pipe 62 but from a different pipe 85. This receives an air suspension of wood fibres from a separate supply of covering stock (not shown) produced from fluffed chemical pulp. The covering stock is used to make boards having a white surface, and dispensers 79 and/or 80 may not be used if no or only one white surface is desired.

The dry forming machine 5 comprises an endless belt 86 of air-permeable fabric passing beneath the fibre dispensers 79, 68a to 68f and 80 and around rollers 87 and 90. The belt comprises the paper-forming surface on which the fibres are laid. The first fibres to be laid are those issuing from dispenser 79. A suction box 91 is mounted behind the belt 86 beneath the dispenser 79 to ensure a constant flow of air through the belt 86. The fibres from dispenser 79 are laid as an entangled layer on the belt 86. The fibres issuing from the dispenser 68a are then laid in like manner on top of the layer just formed. The air from the dispenser 68a passes through the first layer of fibres from dispenser 79 and through the belt 86. The fibres from the dispenser 68a are entangled both with each other and with the fibres deposited from the dispenser 79. In similar manner successive layers of fibres are deposited from the dispensers 68b to 68f and 80. Suction boxes 92a to 92f and 93 are positioned beneath dispenser 68a to 68f and 80, respectively.

After all the layers of fibres have been deposited on the belt 86 they pass beneath a spray head 94 mounted above a suction box 95, which applies a binder for example an aqueous starch binder to the fibres.

At a roller 87 the formed layer of paper board 96, which contains binder but is not consolidated, is separated from the belt 86. The paper board 96 consists predominantly of fibres from the dispensers 68a to 68f, that is to say fibres pulped and dry laid according to the invention. It has white covering

layers formed from the chemical pulp supplied to the dispensers 79 and 80.

The paper board 96 then passes to the consolidating unit 6, where it first passes around a heated drum 97. This carries out some drying of the paper board and pressure rolls 98 and 99 which are in contact with the drum 97 consolidate the paper board. From the drum 97 the paper board passes to a sizing press 100 where size is applied to the paper board 95 at the nip between two rolls. The paper board 95 then passes to a final dryer 104 comprising six heating drums and calender rolls 105 before it is wound on reel 106.

The apparatus shown in Figure 2 comprises generally a pre-heater 201, a thermomechanical pulping macine 202, a dryer 203 and a sheet-forming drum 204. The pre-heater 201, thermomechanical pulping machine 202 and dryer 203 are the same as the pre-heater 1, thermomechanical pulping machine 2 and dryer 3 shown in Figure 1 and described above; the elements designated by the numerals 211 - 261 in Figure 2 are the same as the elements designated by the numerals 11 - 61, respectively, in Figure 1.

The stream of air carrying the separate wood fibres of the pulp emerges from the outlet 261 of the dryer 203, through a pipe 262 leading to the sheet-forming drum 204. The pipe 262 has a convergent portion 263 of fish-tail shape. For example, the cross-section may reduce from 20 x 20 cm in the pipe 262 to 5 x 60 cm at the narrowest point 264. From 264 the air and fibres enter the headbox 265 of the sheet-forming drum 204.

The sheet-forming drum 204 comprises a drum 266 rotating in the direction shown and having its surface in the form of a

air permeable surface 267. Mounted inside the drum 266 is a suction box 268 communicating via a pipe 269 to an exhaust fan 270. The suction box 266 lies behind that portion of the permeable surface 267 which at any one time is passing the headbox 265. The headbox 265 is sealed against the drum 266 at its edges by resilient sealing rolls 271 and 272.

An endless belt apron conveyor 273 passing over rolls 274, 275, 276 is arranged to contact the drum 266 over a portion approximately opposite to the headbox 265 and suction box 268. The wood pulp fibres entering the headbox 265 are deposited on the permeable surface 267 over that portion behind which the suction box 268 lies. The layer of fibres on the permeable surface 267 becomes gradually thicker as it progresses from sealing roll 271 to sealing roll 272. The layer of deposited fibres 277 is then transferred from the permeable surface 267 to the conveyor 273, no suction being applied to the permeable surface in this portion.

The conveyor 273 transports the layer of fibres 272 to pressure rolls 278, 279 which apply pressure sufficient to consolidate the pulp fibres to a coherent sheet. This sheet is carried away from the pressure rolls by a conveyor 280 and is collected at 281.

THE EMBODIMENTS OF THE INVENTION IN WHICH AN EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS FOLLOWS:

1. A process for the preparation of dry wood pulp comprising thermomechanically pulping wood chips and drying the pulp so formed by contacting it with a gas at a temperature of 300-600°C in or at the entry of a high turbulence mixer through which the pulp and hot gas pass and which exerts a shearing action on the pulp to separate fibre bundles in the pulp, the ratio of moisture to dry wood solids being maintained at less than 5:1 by weight throughout the process.

2. A process according to Claim 1 in which the ratio of moisture to dry wood fibre solids is maintained at less than 3:1.

3. A process according to Claim 1 in which the temperature of the hot gas falls to 100°C within one second of contacting the pulp.

4. A process for making paper or paper board in which dry wood pulp fibres are prepared by the process of Claim 1 and are carried through a screen by a gas and deposited as a layer on a forming surface which is permeable by the gas, the layer being subsequently consolidated.

5. A process according to Claim 4 in which the high turbulence mixer used as a drier directly feeds the paper-making or board-making process.

6. A process according to Claim 4 in which the shives and agglomerated fibre bundles which do not pass through the screen are re-cycled to the thermomechanical pulping apparatus.

7. A process according to Claim 4 in which the thermomechanical pulping apparatus and high turbulence mixer feed a plurality of paper-forming or board-forming machines and the fibres from one such machine are deposited on the layer of fibres previously deposited by another such machine.

8. A process for the preparation of sheets of pulp for fluffing comprising preparing dry wood pulp according to claim 1 and depositing the pulp issuing from the high turbulence mixer on a gas permeable surface as a layer, the high turbulence mixer being used as a drier.

9. A process according to Claim 8 in which the gas permeable surface is that of a vacuum drum.

10. A process according to Claim 9 in which the vacuum is only applied to part of the drum and the layer of wood pulp fibres is taken off the drum at a point where suction is not applied.

11. A process according to claim 8 in which the pulp is deposited as a layer having a basis weight of 500 to 5000 gm. per square metre.

12. A process according to Claim 8 in which the layer of pulp deposited is consolidated by pressure to a relative density of 0.5 to 1.

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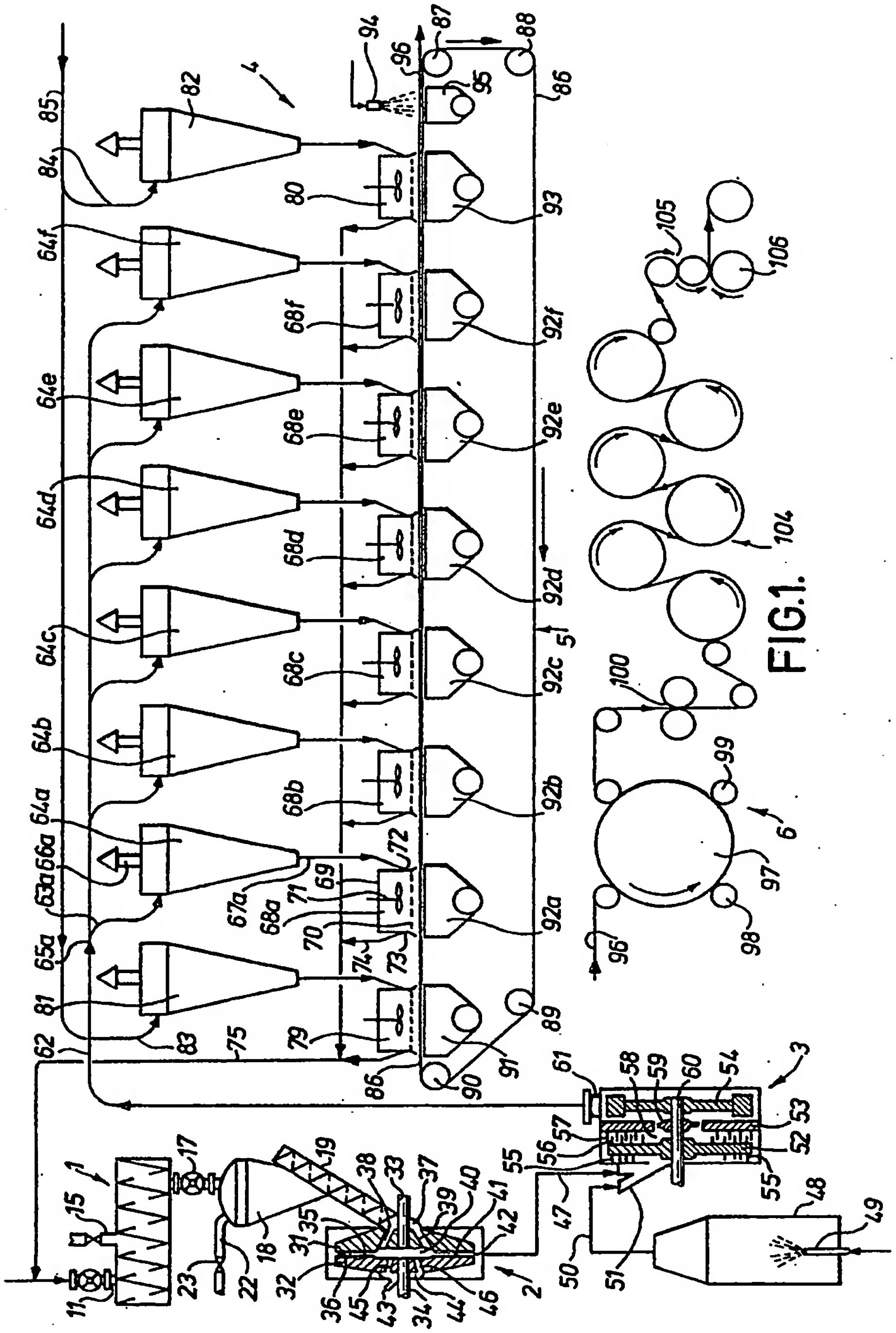

FIG.1.

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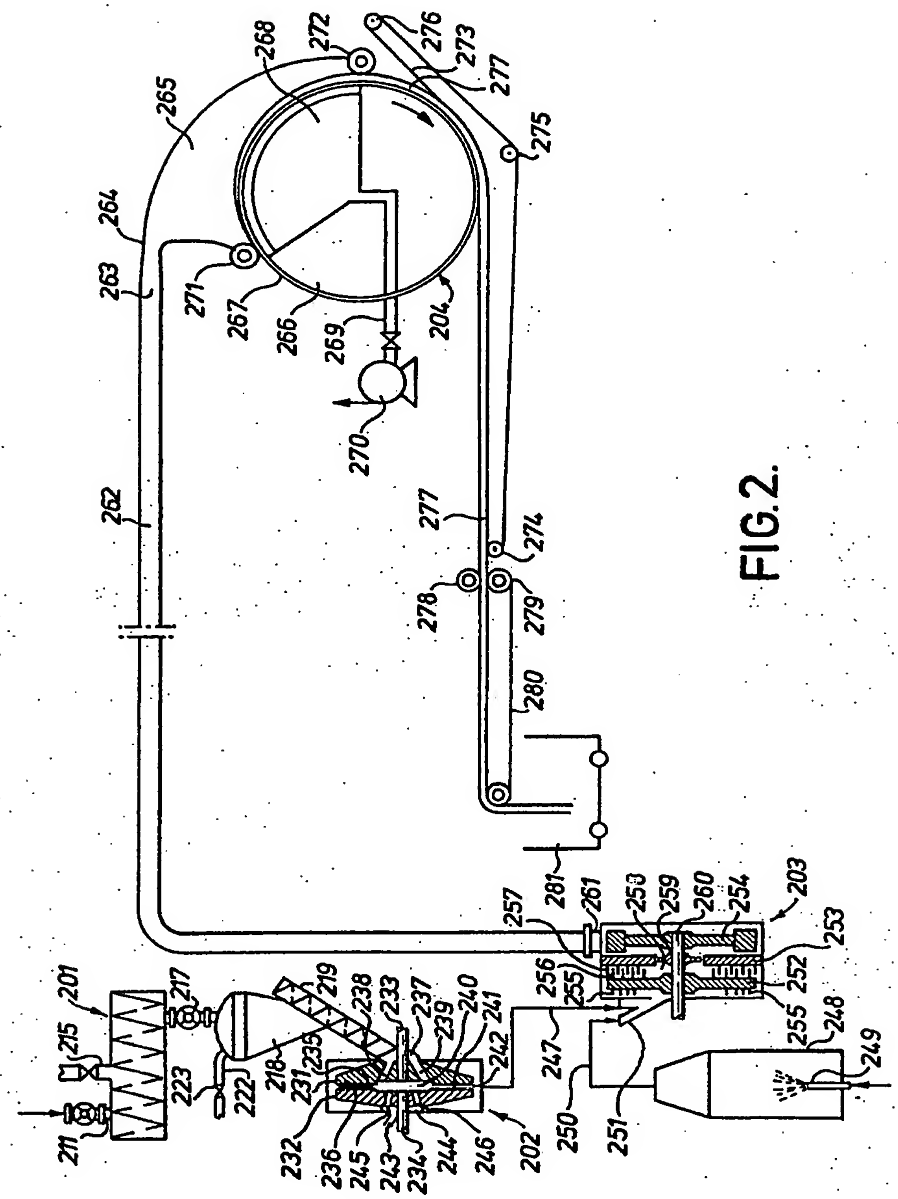

FIG. 2.

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